Chapter 1

INTRODUCTION

A brief background of the problem statement's origin, Demand Side Management Options, Clean Development Mechanisms, Smart Grid, Time of Use, Renewable Energy Resources such as Rooftop Solar. The chapter also explains the research phases, time, research objectives, the methodology adopted, scope, and limitations.

Background of the study

1.1 Demand Side Management

Demand side management (DSM) is the planning, implementation, and monitoring of utility activities designed to influence customer use of electricity in ways that will produce desired changes in the utility's load shape, the time pattern and magnitude of a utility's load (Gellings, 1985). The goal of DSM is to encourage the consumer to use less energy throughout the peak hours or change the time of energy use to off-peak times such as nighttime and weekends. Peak demand management does not primarily decrease total energy consumption. However, it is expected to reduce the cost of investments in networks and/or power plants to meet peak consumers' demands. For example, the energy is stored during off peak hours and discharged during peak hours (Taylor, 2018). Energy management practices like better efficient systems and automated controls can be used by consumers for the reduction in and better control of energy.

Homeowners can switch off the electric water heater or increase thermostat set points for the air conditioning system to save energy. These actions might be done at the homeowner's convenience, e.g. when demand for, say, hot water drops, or the utility might provide incentives to customers who use electricity rate during the peak period (Khalid et al., 2019). Thus, by giving appropriate storage capacity controls, the user could meet hot water requirements by off-peak electricity use. The air conditioning controls could inevitably decrease the temperature to begin cooling the house during the off-peak electricity shortly before occupants return. There are different ways to implement and manage the demand side, among which are Smart Grid, Time of use (ToU), Solar, Energy Storage (Taylor, 2018), and Efficiency facilities (Vijayapriya & Kothari, 2011) (Smith and Parmenter, 2016).

There are many reasons utilities pursue DSM programs (Eto, 1996). All the reasons are not applicable to all the utilities, and whenever applicable, that depends upon the importance of the reasons. Many utilities adopt several factors, such as;

1. DSM programs are cost-effective.
2. DSM programs increase customer satisfaction.
3. DSM programs are helpful in reducing the environmental impacts of siting a power plant as well as its use.
4. Government regulatory requirements will encourage utilities to implement DSM programs (Steven Nadal, 1992).

Cost-Effectiveness

Utilities have spent many decades searching for inexpensive sources of power and optimizing power plant designs. Efforts to optimize energy efficiency in customer facilities have rarely received the same level of attention. As a result, many efficiency opportunities are available on customer's meter, which costs substantially less per kWh saved than the cost to generate a kWh from a new power plant. In some cases, the amount spent on efficiency measures cost less than the actual amount of operating an existing power plant. For example, the New York State Energy Plan estimates that power from new power plants ranges in cost from $0.05 per kWh to more than $0.10 per kWh, depending on the type and nature of the facility, but for DSM programs, it ranges from $0.014 to $0.050 per kWh. The study further reveals that operating costs for any existing power plants are usually $0.03 per kWh or more. Therefore, several DSM programs are cheaper in terms of per kWh than existing generating facilities. Moreover, owing to large construction-cost disallowances throughout the 1980s, more than $13 billion of power plant capital investments were denied cost recovery by state and federal regulators). Many utilities are fearful that construction costs for new plants may not be allowed (Reddy, 1996) (Steven Nadal, 1992). Cost disallowances increase the amount of newly established power plants to stockholders, thereby making the DSM programs finance even more appealing to utility managements.

Customer Satisfaction

DSM programs are popular with customers because they encourage energy conservation, which will reduce customer energy bills, and, in some cases, promote the installation of new equipment by utilities, which provides additional advantages to households aside from the energy savings. For example, because of a DSM program, customers may receive efficient new lighting fixtures that cause less glare than the fixtures they replaced; or a weatherization job may decrease drafts in a home, making occupants more comfortable. Furthermore, in an era when cleaning up the environment enjoys broad public support, DSM programs often play prominently in utility efforts to improve their environmental image (Harding et al., 2019). Utilities, for many reasons, practice customer satisfaction. First, in the case of large customers, utilities fear that customers will leave the utility grid and either generate their own power or (if the electric utility industry is deregulated) purchase electricity from an alternative supplier, thereby decreasing sales and hurting profits. Unhappy customers are more likely to bypass the utility than happy customers. As a result, some utilities offer DSM programs as a "plum" to customers who would possibly bypass the utility grid. Second, utility commissions often respond to consumers concerns. An illustration of this phenomenon is provided by General

Public Utilities, which substantially expanded DSM programs in the wake of the accident at their Three Mile Island Power plant (Steven Nadal, 1992).

Environmental Impacts

New power plants may have some difficulties in starting operations due to the issue of having the site and permit. At the same time, pollution of air and water, and fly ash waste disposal problems are often associated with power plants (Mahapatra et al., 2012). DSM programs helps in reducing these problems by reducing the amount of power that is needed. Under the Clean Air Act Amendments 1991, utilities are advised to implement DSM programs as part of their regulatory requirements. Many studies have found that DSM programs can be less costly per ton of sulfur dioxide removed than scrubbers(Harding et al., 2019). Additionally, several states instruct utilities to include estimates of the value of avoided emissions and other environmental externalities when conducting cost-benefit analysis on DSM programs(Garg et al., 2014). New England Electric's most recent strategic plan demonstrates the importance of these factors; the cornerstone of the goal is to reduce electric service's environmental impact. DSM programs feature prominently among the implementation strategies listed (Harding et al., 2019).

Regulatory Encouragement

Many state regulatory commissions support DSM programs because of the three factors mentioned above. As a result, commissions have employed a variety of stimuli to encourage utilities to implement DSM programs. These include direct orders to implement DSM programs, financial penalties for not implementing DSM programs, "least-cost planning" requirements under which power plants must implement DSM programs if they are cheaper than supply-side alternatives (Reddy, 1995). Here the condition is that the environmental externalities be included in analysis underpinning resource acquisition decisions and financial incentives for implementing DSM programs. In addition to regulatory encouragement, interveners in the regulatory process may also seek expansion of DSM programs. Sometimes utilities find it preferable to work with interveners on detailed DSM implementation plans as an alternative to contentious hearing room battles over DSM issues.

1.2 Smart Grid

Smart Grid aims to integrate advanced networking technologies into electrical power grids to make them smart to use both customers and utilities. In the current situation, with better communication devices and electrical grid technologies, electricity failures, blackouts, and voltage sags could be avoided. In order to convert the current electrical power grid into a smart grid, both the design and implementation of a new communication infrastructure needs adequate research attention. However, smart grid projects have only been proposed in recent years, and only a few proposals were considered for initial research work that have been offered in this field (U.S. Department of Energy, 2014). Smart Grid is a data communications system integrated with the power grid that collects and analyzes data captured in real-time about power transmission, distribution, and consumption. Based on these data, smart grid technology then provides predictive information and recommendations to utilities, their suppliers, and their customers on how best to manage power (Khan, 2019). From another perspective, Smart Grid is a complex system of systems. The National Institute of Standards and Technology (NIST) has developed a conceptual architecture for the entire smart grid. This conceptual architectural reference model provides a means to analyze use cases, identify interfaces for which interoperability standards are needed, and facilitate a cyber-security strategy. There is a shortage or little study on the systematic reviews of communication/ networking in smart grids. Therefore, systematic review of smart grid, including communication/networking architecture, different communication technologies that would be employed into this architecture, quality of service (QoS), optimizing utilization of assets, control, and management, etc. is required (U.S. Department of Energy, 2014).

1.3 Clean Development Mechanism

The clean development mechanism (CDM) under the Kyoto Protocol to the United Nations Convention on Climate Change (UNFCCC) allows developed countries with a greenhouse gas reduction commitment to invest in emission reducing projects in developing countries as an substitute to what is generally considered costlier emission reductions in their own countries (Sutter & Parreño, 2007). These carbon credit mechanisms are project-based, intending to provide financing for project activities that will cut off carbon emissions, in which renewable energy (RE) is an essential component (Winkler & Van Es, 2007). Due to the availability and prevalence of resources, solar energy is widely regarded as the best option for these mechanisms. However, the role of Kyoto Mechanisms to develop solar energy has remained relatively small as compared to other RE projects, such as wind (Sutter & Parreño, 2007)(Dey, 2013)(Castro, 2014). The CDM is designed to start developing countries off on a path towards less pollution, with industrialized countries paying for the reductions (Schroeder, 2007). The Overall purpose of the mechanism is to enable cost-effective reductions of greenhouse gases, meanwhile contributing to sustainable development in a developing country. Renewable energies are central for the conversion towards low carbon economies because they lower the possibility of fossil fuel consumption. However, in the presence of any other emission trading scheme, the CDM allocates a price on emission drops so that CERs become a service that can be transacted. It provides extra financial enticement to developers of RE projects in developing countries. CDM projects reduce not only greenhouse gas (GHG) emissions cost-efficiently and enable Annex I countries to meet their emission reduction targets. But they can also be drivers for emerging RE markets in the CDM host countries (Sutter & Parreño, 2007). The CDM is a mechanism that provides additional finance and brings together project developers, validators, and project investors from developed and developing countries (Castro, 2014). While unilateral

CDM projects are also encouraged, bilaterally implemented CDM projects are ideal for facilitating knowledge exchange and technology transfer among partners and creating new business opportunities. Renewable energy projects deliver not only emission reductions, but also sustainable development benefits to their local environment (Tatrallyay & Stadelmann, 2013). In this regards, the CDM, RE projects support domestic sustainable development e.g., by providing access to electricity and heating in remote places or by creating job opportunities in the local RE industry. RE CDM projects should therefore be considered to be the core of the CDM project fleet, as the Kyoto Protocol mandates the CDM with a dual goal emission reduction and sustainable development, which RE and energy efficiency projects are best able to achieve (Carstens et al., 2014).

1.4 Time of Use

The electricity market has a fascinating feature that the supply and demand must be balanced in real-time to avoid damage to the distribution grid. Considerable quantities of electricity are expensive to store over time. Besides, while consumers generally pay fixed prices, production costs can vary significantly over a day. The gap between market price and varying marginal cost leads consumers to over–or under–consume electricity at various parts of the day. This consumption model carries high social costs, as electricity generation is costly in terms of pollution and resources. One policy suggestion intended to balance production costs and market prices is introducing dynamic prices for electricity consumers. Efficiency can be improved by deterring power consumption during peak demand periods and encouraging more significant usage during off-peak periods. Dynamic pricing consequently incentivizes households to reduce the variance of electricity demand from hour to hour. With the implementation of smart meters that allow two-way communication between utility companies and customers, dynamic pricing for electricity is now technically viable. While dynamic pricing is increasingly common among utilities, it is still not usual for consumers to face pricing that matches the wholesale market in real-time. The unpredictability of the wholesale market, where prices are computed multiple times in a five-minute interval, would convey a significant amount of risk to consumers in the form of unpredictable electricity bills. Instead, many utilities have used randomized control trials and pilot programs to examine consumer responsiveness to “time of use" programs. Under ToU pricing, consumers face elevated prices during peak hours and reduced prices during off-peak periods. The desired behavioral response encouraged by dynamic pricing may lead to unintended environmental consequences (Khalid et al., 2019).

During summers, peak demand generally usually occurs during the afternoon, when solar power production is a significant contributor to power generation. Shifting consumption to the evening or early morning hours may increase electricity generation via dirtier nonrenewable power sources. Reallocating consumption to off-peak hours may hence offset the environmental benefits of conservation during the peak hours (Matt Harding, 2019).

ToU is meant to change consumers' behavior and ease the energy usage required at its most in-demand time. This helps to reduce the probability of power outages as well as over-generation of power supply. ToU is the segregation of energy rates based on the time in which the energy is being consumed, a way in which utility providers attempt to alleviate demand during peak periods by implementing a tariff structure that charges an increased rate within the typical peak consumption periods. ToU is categorized into three systems, namely, peak, off-peak, and mid-peak. These ToU groupings differ based on region and have become progressively deployed in utility electricity charges. ToU has become an efficient way for utility providers to manage their power production, record energy consumption, and allow consumers to control their energy bills. This control has made consumers cut their energy costs by studying their energy consumption and using peak analysis tools. Consumers applied the load shedding method by alternating the use of machines at off-peak hours whenever possible.

Time of Use Tariff

Time of Use tariffs applies different prices for electricity at other ToD. The time is divided into Peak, Shoulder, and Off-Peak periods that reflect the electricity network level. Price of electricity during the off-peak periods is always cheapest among all. Under the national electricity rules, electricity networks must be built to handle the highest demand peaks. This implies that tariffs must show a combination of the total electricity being used and the utility's peak rate. When customers run many appliances at the same time, they increase the peak demand on the network. Thus, the more efficiently a customer uses electricity, the less effect they have on the electricity network. Therefore, ToU tariffs have more advantages in setting prices for customers than standard flat rate or block tariffs.

Essential Energy's Time of Use tariffs

- Essential Energy offers a range of tariffs that have been designed for different types of customers, considering their energy consumption and/or demand profile, voltage level, and type of connection to the network.
- To take the advantage of ToU tariffs, a meter is required. Most of the residential and small business customers have necessary accumulation meters, which requires an upgrade.
- Consumers with a time of use capable meter can choose to move to a ToU tariff at any time.

Breaking Down Time of Use

ToU is fragmented into three main groups based on time of day and amount of electricity demanded. These segments are peak, off-peak, and mid-peak (also referred to as shoulder time).

- Peak rates are the time of the day when energy demand is the highest. This is usually late afternoon into the evening when people get home from work and start using their electrical devices more heavily. During this period, local distribution companies charge the highest rate for the electricity consumed.

- Off peak, rates are during the time of day when energy demanded is the lowest. This is usually late morning into early afternoon when the energy is required is lower due to significantly fewer people being in their homes.
- Mid-peak, or shoulder time, rates are during the time of day when energy demand is ramping up or ramping down.

Expensive rate due to peak load

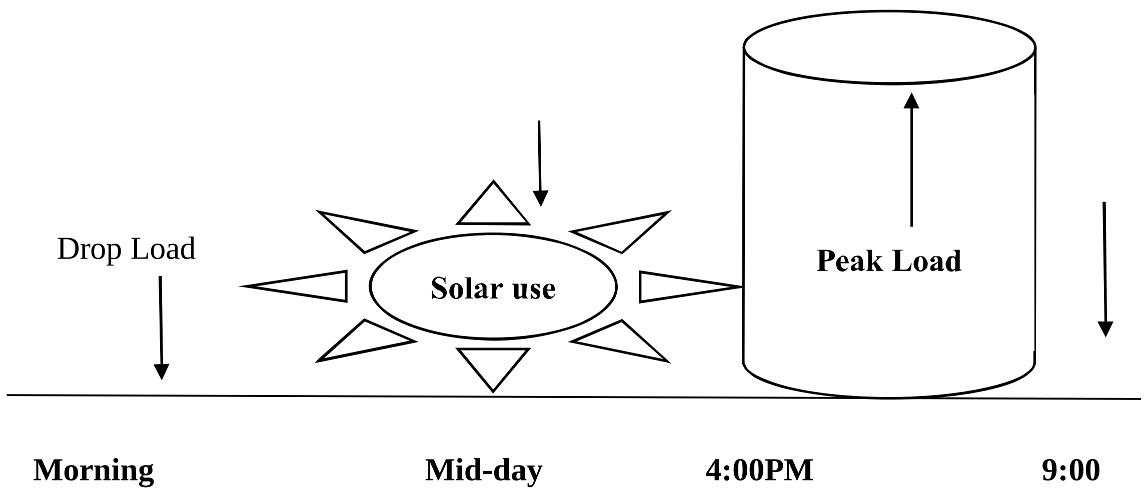

Figure 1.1 Time of Use

Below is an example of Energy saved after ToU concept has been implemented and applied.

Table 1.1 Example of Time of Use, Jalgaon MIDC

Consumer	Actual Consumption	Optimized Consumption
1	15272	13222
2	25748	21454
3	57245	55745
4	26590	25765
5	26880	24876
6	27762	25656
7	31495	28654
8	21059	17365
9	30740	27656
10	19739	17111
11	19901	16656
12	18521	16452
13	26648	24909
14	36260	34789
15	55194	52909

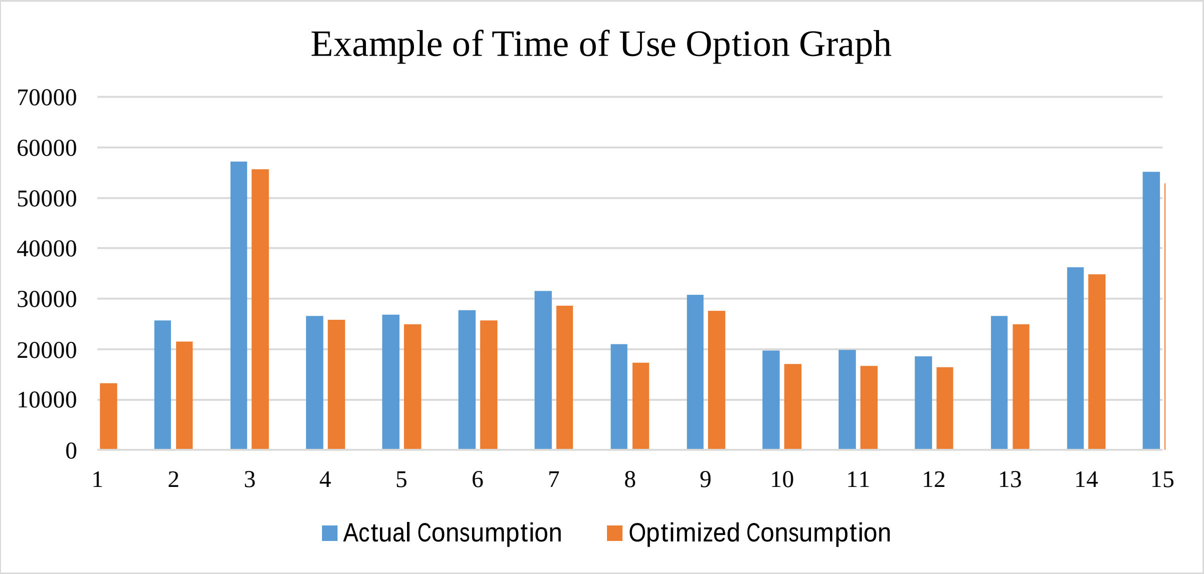

Fig. 1.2 Example of Time of Use, Jalgaon MIDC

Energy saved graph from the ToU table

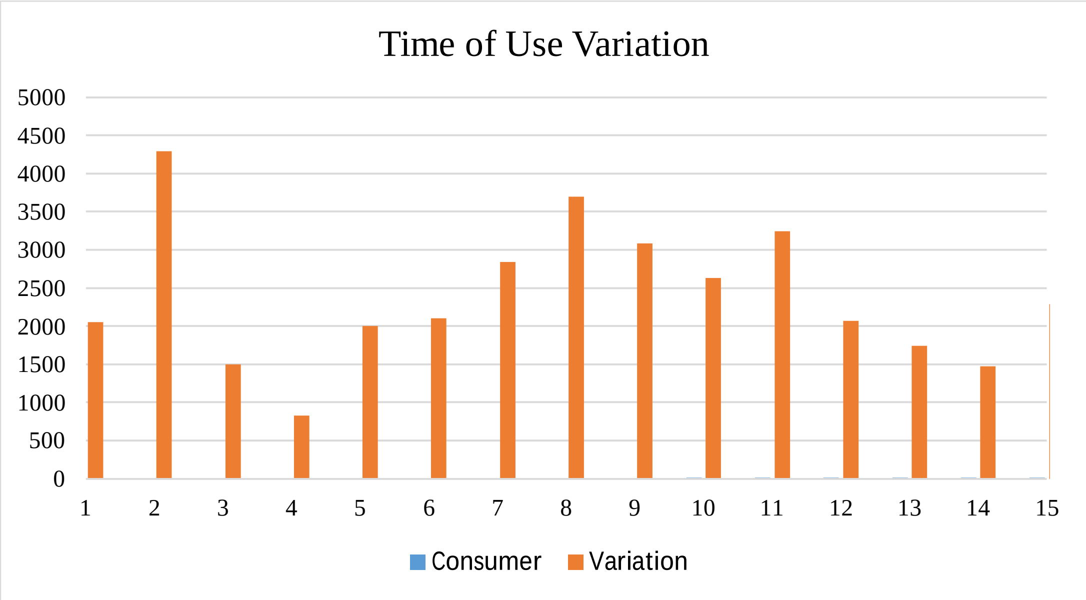

Figure 1.3 Example of Time of Use Variation

1.4.1 *Benefits of Time of Use* (Reddy, 1996)

- *Lower Electricity Bills*: ToU provides people options to save by conserving and shifting energy use to cheaper times of the day. By focusing more on the timing of energy use (Esther & Kumar, 2016).
- *Freedom of Choice:*

  energy choices if they choose to. Consumers will have the option to opt-in or opt-out, effectively choosing how they intend to pay for electricity. ToU provides more payback for rooftop solar over the tiered rates, as solar energy can help customers avoid expensive peak energy times (Khalid et al., 2019). Also, ToU could enable more prospects for customers to save money and stay comfortable, such as using smart thermostats to pre-cool homes in advance of high-demand, peak energy times.
- *Clean, Healthier Air for All:* ToU pricing helps reduce the need for fossil-fueled power plants by selecting to use electricity when renewable energy is not available and opting for other clean energy solutions like energy efficiency. Even those who choose not to

participate in ToU will benefit from healthier, cleaner air. ToU could succor to communities residing near power plants because they support the community with a health burden from breathing in toxins from these facilities. Power plant emissions have been linked to premature death, worse lung and heart disease, bronchitis, and asthma (especially in children), and an increased number of missed school and workdays (EDF 2020).

1.5 Rooftop & Streetlight Solar

Solar street lights were initially used mainly in third world countries, in remote areas or where electricity is not always available, or supply is unreliable (Rajeev & Nair, 2012a). Today's solar technology has evolved, and solar projects are appearing in developed as well as developing countries. Solar panels have recently been designed to be installed on streetlights of various sizes and wattages. Solar streetlights are photovoltaic (PV) powered panels generally mounted on the lighting structure to ensure safety in the night. Most of them have light detectors, which indicates how bright it illuminates outdoors; this is to avert any form of concern about turning them on or off because they will turn on in the evening and off automatically in the daytime. Lighting is an essential requirement for all industrial as well as residential use. Due to advancements in the field of lighting, there has been rise to tremendous energy-saving opportunities in this direction. Lighting systems are designed to minimize life cycle cost at the same time meeting the intended lighting requirements (providing the least minimum luminance requirements to ensure proper functioning and safety of users). It is prudent to select the appropriate lamp and ballast combination that generates high lumens per watt and a fixture that meet the design requirements and minimize glare, light trespass, and possible light pollution to obtain effective energy efficient design. In Solar LED Lighting, solar energy is used to charge a self-contained battery during daylight; at night, the battery powers the streetlights. Solar LED street lighting is a unique cost-effective solution for many places such as parking lots, parks, residential streets, airports. Other benefits of these types of LEDs are ease of installation, no need to dig trenches, lay underground cables, and immunity to power outages (Rajeev & Nair, 2012a).

Energy analysis of rooftop photovoltaic system

A rooftop PV system can be designed to supply the domestic load requirement. The system contains 12 PV modules (area of each PV Module is 0.61 m^2), a charge controller (efficiency – 84%), a battery (150 Ah), an inverter (efficiency – 85%), and load (single-phase AC operated). The block diagram of this system is shown below in the fig. 1.4.

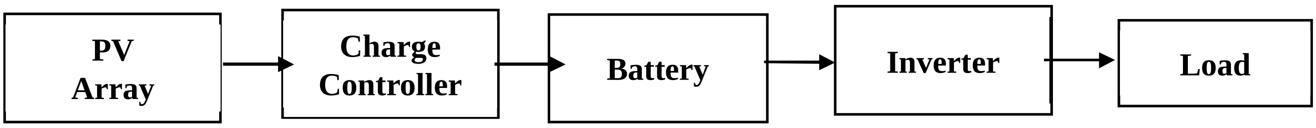

Fig.1.4 Block diagram of rooftop photovoltaic (PV) system

1.5.1 *Description of different components of Installed PV System*:

PV Array: PV modules are connected in parallel and mounted on an inclined structure in this system. The inclination of the system is kept at the latitude of the location to receive maximum annual insolation.

Charge Controller: This device regulates the flow of electricity from the PV array to the battery and the load (Byrne et al., 2019). This controller is used to keep the battery fully charged without overcharging it. When the load is drawing power, the controller allows the charge to flow from the PV Array into the battery, the load or both (Rajeev & Nair, 2012a). When the controller senses that the battery is fully charged, it reduces or stops electricity flow from the PV Array. A charge controller should be used to power DC equipment with solar panels (Yazid et al., 2014). The charge controller provides a DC output (regulated) and excess energy is stored in a battery, also it monitors the battery voltage to prevent under /overcharging, it will also perform maximum power point tracking.

Inverter: An inverter can be used to generate AC electric from DC electricity which we get from sources like batteries. It can operate the AC equipment designed for regular operation or rectified to produce DC at any desired voltage. A PV inverter is a vital component in a photovoltaic system. It converts DC output of the solar panel into a utility frequency alternating current that can be fed into the commercial electrical grid which can be used by a local, off-grid electrical network. "Solar inverters have special functions to be used with PV arrays, including maximum power point tracking" (Dioha & Kumar, 2018)(Rajeev & Nair, 2012b).

- Stand-alone inverters used in isolated systems where the inverter draws its DC energy from batteries charged by photovoltaic arrays. Many stand-alone inverters incorporate integral battery chargers to replace the battery from an AC source when it is available.
- Maximum power point tracking is a technique that solar inverters use to get the maximum possible power from the PV array. There is a complex relationship between solar irradiation, temperature, and total resistance in solar cells, which produces a nonlinear output efficiency called the ***I-V curve***. This is one of the essences of the MPPT system to sample the cells' output and apply resistance in the form of the load to obtain maximum power for any given environmental conditions. Essentially, this defines the nature and the amount of current that the inverter will generate from the PV to get the maximum possible power (since power equals voltage times current).

Battery: A battery is used to store electricity produced by the solar system. The battery's energy storage capacity is measured in watt-hours, which is the amp hour rating times the voltage (Janocha et al., 2016).

Working of Installed PV System: PV Modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The charge controller handles the output of PV Array. The charge controller regulates rates of flow of electricity from the PV array to the battery and the load. The controller often keeps the battery fully charged without overcharging it. The charge controller's output is then transmitted to the Battery, which housed the electricity produced by a solar system. Now the battery output relates to inverter input. An inverter converts the DC electricity from this AC output of Inverter is directly provided to the load connected with it (Hussain et al., 2018).

Table 1.2 Average hourly data of installed solar system

S.N.	**Time**	**Intensity (W/m^2)**	**Short Circuit Current, Isc (Amp.)**	**Open Circuit Voltage, Voc (Volt)**
1	09 am	500	23.20	19.80
2	10 am	640	34.60	19.60
3	11 am	820	42.50	19.40
4	12 noon	895	46.50	19.60
5	01 pm	860	47.60	19.40
6	02 pm	740	44.60	19.40
7	03 pm	620	34.20	19.50
8	04 pm	360	18.20	19.20

Limitations of solar photovoltaic energy conversion (Yazid et al., 2014)

- Irregular supply of solar energy.
- Require battery storage for supply power at night.
- Low efficiency.
- Require large area.
- Do not generate power during cloudy season.

1.6 Renewable Energy Sources

The world is moving in the direction of using electricity derived from renewable sources (Luz & Moura, 2019). With the mass production of the devices to allow energy production from such sources (wind, solar and tides), peak power capacity will be extremely competitive with electricity from fossil fuel. The problem is that the profile of power produced from the two sources cannot match that of the requirements (from industries and households). This has been an existing problem, but it has become more acute: due to the extremely peaky nature of the power from the new sources, it is necessary to maintain the capacity to generate power to cover the full load in certain climatic conditions unless there is efficient energy storage. While nuclear power is clean and would be ideal for satisfying base load requirements, nuclear plants' capital cost (which should include that of decommissioning) makes the real amount of such power is more expensive than the one obtainable from renewables. Since time immemorial, companies often device best ways to efficiently store energy to deliver on-demand with less capital investment. To meet the everyday needs of energy, a wide range of technology is developed and employed. Energy storage resource allows electricity from any power source more efficiently, but this involves considerable capital investment. Most of the population has taken up the idea of moving towards reliance on renewable energy. But more need to be done, especially about the essential corollary of energy storage. Also, there is the challenge of storing energy that needs to be investigated; these include the issue of maintaining the equipment and the longevity of the equipment used for producing the energy and storing it (Taylor 2018). Electricity is the most prominent form of final energy being used in the modern world. The electricity demand has been increasing worldwide continuously at the rate of 3% per year due to the expanding industrialization, multiplying population and day by day improvement in human comfort level. To meet the electricity demand, the worldwide electricity generation had also increased from 6,131 TWh in 1973 to 25,551 TWh in 2017. Despite increasing electricity generation, it is estimated that out of the total 7.6 billion world population, 1.2 billion people are deprived of electricity, and about 2.7 billion people still rely on traditional fuels and energy sources, such as biomass, for most of their energy requirement. India is the second most populated country in the world having approximately 18% of the world's total population and consumes only 6% of the total energy. India's total installed capacity for electricity generation is 356.10 GW as on 31.03.2019, out of which 226.28 GW is from fossil fuel-based power plants. So, almost 66% of India's electricity comes through fossil fuels only. Same holds for the world where fossil fuel sources contribute more than 65% of the world's electricity, while the rest of the total electricity generation is through renewable, nuclear, and other sources (CEA, 2021). The carbon emissions from these fossils' fuels-based power plants are harmful to the environment and society (Garg et al., 2014).

Renewable energy sources have gathered considerable attention from governments, utilities, and researchers to provide a clean energy source and reduce emission and other environmental concerns associated with fossil fuel-based power generation. During 2008, the total installation of renewable power generation capacity in the world was 1,057 GW, which rose to 2,179 GW in 2017, due to the widespread promotion of RE across the world by various agencies. According to the international RE agency, with 80.18 GW (as of 31.03.2019), India stands sixth in the world in the total installed renewable power generation capacity. In the Indian context, it is predicted to increase renewable electricity generation to 175 GW by 2022. This includes 100 GW from solar power, 60 GW from wind power, 10 GW from bio-power, and 5 GW from small hydropower. As of March 2019, RE sources' total installed capacity includes 35.62 GW from wind power, 29.69 GW from solar energy, 10.26 GW from bio-power, and 4.59 GW from small hydropower (CEA, 2013) (MoP, 2020).

Energy consumption is one of the significant ingredients of development, so an increase in energy use has many benefits; people become increasingly informed about the negative impacts of energy use. These impacts are experienced globally in the form of climate change (and the associated effects) and degradation of local environments in terms of poor air quality, degradation of soils, resource depletion (e.g., water), and noise pollution (Mahin et al., 2019). However, efficient use of energy at all stages of the supply /demand chain could reduce the negative impacts of energy consumption, at the same time, allowing even economic development. More so, there would be higher than necessary operating costs if the use of energy usage is not optimum. With higher energy efficiency the operating costs will reduce and RoI will increase at the level of the company. While at national level, improved energy efficiency means reduced energy imports, thereby reducing foreign exchange pressures and increasing the availability of scarce energy resources for others to utilize. This will allow increases in energy-dependent activities that will contribute to the population's economic well-being. Society also benefits from increased energy efficiency through reduced adverse environmental impacts of energy usage. Lastly, at the global level, primary energy resources (mainly fossil fuels) that are finite will eventually be exhausted. They are essential ingredients on which our lives and economies depend. However, constant, and accelerated use in recent years makes it outdated and reduced availability with higher costs creating serious pressure to rely on fossil fuel imports. Sustainable future development depends on using these resources wisely and maximizing the benefit received for each unit of energy consumed (Halkos & Gkampoura, 2020).

1.7 Problem statement

India is the second most populous country globally, with the highest annual global radiation from the country's northwestern part. Although demand for electricity supply is on the rise every day, the authorities have not yet figured out how to manage the efficient generation and distribution of electricity in an economical manner that will be less harmful to the populace.

New technologies are being implemented every day in the energy field, which solves global warming, managing loads, pollutions, and other energy-related problems. The lack of awareness between the people and the authorities on managing and utilizing electricity has resulted in the loss of billions of dollars and citizens' lives due to radiation.

To overcome the current issues, there is a need to develop a system which would provide the use of RE sources, such as rooftop/streetlight solar, battery storage capacities, and a system which would provide the authorities and the people an efficient way to manage their loads, e.g., using CDM, Smart Grid, and DSM. Also, a program should be put in motion to create massive public awareness by the authorities on the importance of resorting to RE sources and using low energy consumption appliances, saving more energy and more units in their pockets.

1.8 Objectives of the Research

The overall objectives of the research are

- To assess the feasibility of various Demand Side management (DSM) options under the current utility framework.
- To assess the energy and environmental savings through DSM under a series of scenarios. These scenarios include a range of planning options such as: energy efficiency, T&D loss reduction and renewable energy technologies.
- To assess the techno-economic feasibility of DSM programmes under different market conditions and its impact on different market players.

1.9 Methodology adopted

The proposed work has been divided into six phases**:**

Phase I: There will be an extensive literature survey in energy efficiency techniques, renewable technologies (like solar and wind), and to estimate the impact on DSM.

Phase II: This phase will deal with the survey of various existing models for DSM, and comparison will be made.

Phase III: The suitable algorithm will be developed for the model during this period. The model will develop, and data will be collected.

Phase IV: The analysis will be carried out with collected data during this period.

Phase V: During this period, various scenarios will be generated, and a CDM-based analysis will be done.

Phase VI: In this last phase, suitable conclusions and/or recommendations based on above analysis will be drawn with thesis writing and the final thesis would be submitted.

It is expected that the model will predict the outcomes of DSM implementation with CDM approach.

1.10 Scope and Limitation

Scope

Demand-Side Management indicates a radical and innovative approach to planning at electric utilities. Essentially, it widens the scope of planning to integrate the customer's needs and desires with the utility's goals. This research examines information, techniques, and guidelines for use in DSM planning and execution. It looks at some significant types of DSM programs, from the smart grid, RE sources such as solar, battery storage, and appliance efficiency programs to interruptible rate and strategic marketing efforts. Special features include: What to expect in energy renewable source options, customer load control options, and electric load impact of new technologies.

Limitations

- Despite the potential cost savings, Consumers must have a dedicated resource and knowledge to use DSM technology (Khan, 2019).
- DSM is better suited for larger energy consumers or those with complex energy needs. DSM has limited benefits for smaller consumers and is not always worth the price.
- The amount of solar energy that could be collected. The sun's radiation is fixed; the location where panel can be used to pave solar panels is limited; entire sunlight cannot be exploited for electricity because of biosphere needs; the energy conversion efficiency has a theoretical limit. Such a limit is beyond the energy human needed.
- RE depends on weather conditions, and unpredictable weather conditions for a long time could lead to energy deficiency.

1.11 Organization of the Thesis

Keeping the broad research objectives in mind, the thesis consists of seven chapters. Fig. 1.5 illustrates the thesis structure.

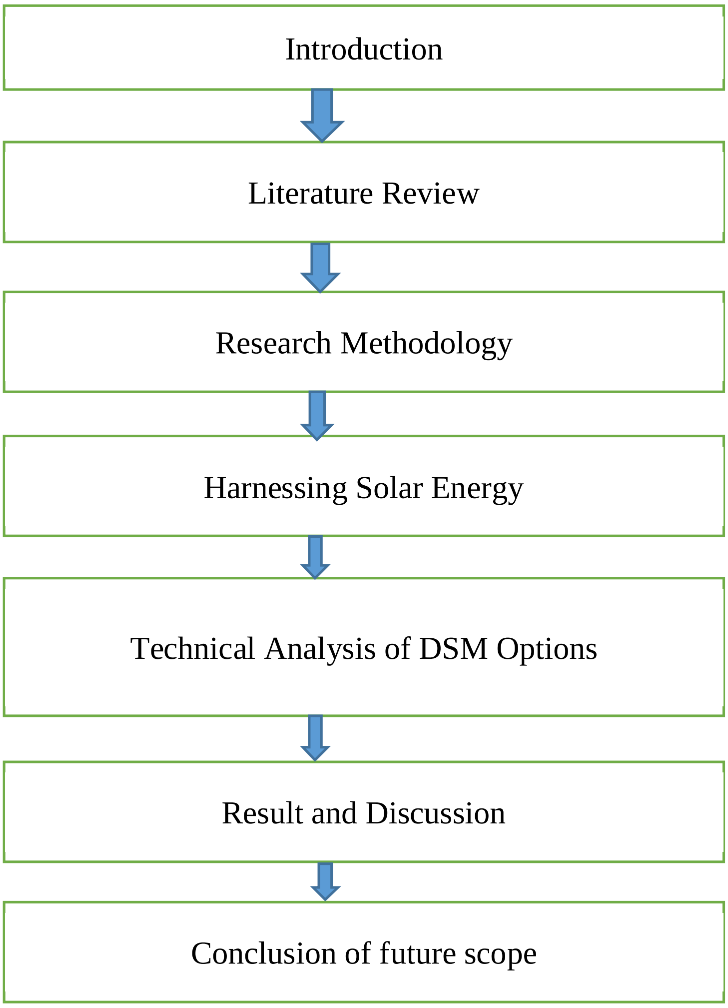

Fig. 1.5 Thesis structure diagram

Chapter 1: A brief background of the origin of the problem statement, Demand Side Management Options, Clean Development Mechanisms, Smart Grid, Time of Use, Renewable Energy Resources such as Rooftop Solar. The chapter also explains the phases of the research, time, research objectives; the methodology adopted, scope, and limitations.

Chapter 2: This chapter represents a technical review of the preceding research work conducted in the following areas:

- Demand Side Management
- Clean Development Mechanism
- Time of Use
- Solar Energy
- Renewable Energies Resources, and
- Gaps identified for addressing it in present research work.

Chapter 3: This research aims to demonstrate the feasibility of the previous chapter's DSM options.

Chapter 4 discusses the Solar Energy background, harnessing its potentials, and discusses challenges, cash flow, and limitations.

Chapter 5 provides a technical analysis overview on Demand Side Management Options, such as Photovoltaic Solar and Energy Efficient Technologies.

Chapter 6 This chapter discusses the result and discussion. In this chapter, results obtained from various Demand-side options have been discussed. Inferences and Recommendations discussed.

Chapter 7 This chapter discusses the conclusion drawn from the present research work and incorporates the possibility for the future scope of the work.